NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

January 30, 2015

Group Chairman's Factual Report

STRUCTURES

DCA13MA081

Attachment 9

Boeing Presentation 747-400 BCF MRAP Tie Down Assessment for NTSB
August 2014

747-400 BCF MRAP Tie Down Assessment for NTSB

Aug 2014

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747-400 BCF MRAP Tie Down Assessment for NTSB

NTSB Request

1. A presentation/analysis is requested to include an assessment of the possible Cougar and M-ATV (MRAP ATV) restraint options consistent with the WBM & ATTLA documentation versions available at the time of the accident.
   - Boeing Weight and Balance Manual – D043U544-AFA1, Revision 9 July 20, 2010
   - Telair Weight and Balance Manual – 25-55-66, Revision L, February 10, 2009
   - Internal Air Transport Certification (ATTLA) – 2007.07.18.01, August 6, 2009
   - Internal Air Transport Certification (ATTLA) – 2009.08.32 Rev 7, September 28, 2012

2. The same analysis, with the added assumptions that the M-ATV auxiliary tie downs are available for use (per ATTLA documentation).
   - Boeing Weight and Balance Manual – D043U544-AFA1, Revision 9 July 20, 2010
   - Telair Weight and Balance Manual – 25-55-66, Revision L, February 10, 2009
   - Internal Air Transport Certification (ATTLA) – 2009.08.32 Rev 8, June 25, 2013

747-400 BCF MRAP Tie Down Assessment for NTSB

Response to NTSB Request Summary

- Three cases were assessed in support of the NTSB request's
- NTSB request #1 assessed tie down restraint for the Cougar and M-ATV vehicles.
  - Zero Cougar vehicles can be carried, due structural limitations of the aircraft when considering the size and weight of the vehicle.
  - One M-ATV can be carried using tie down restraint. 60 restraint straps required in this assessment
- NTSB request #2 assessed tie down restraint for the M-ATV vehicle, allowing use of the auxiliary side tie down locations on the vehicle.
  - One M-ATV can be carried using tie down restraint when considering the additional auxiliary tie down locations. 56 restraint straps required in this assessment

747-400 BCF MRAP Tie Down Assessment for NTSB

Cougar and M-ATV Dimensions and Weights

- Cougar CAT 1 with Independent Suspension System (ISS)
  - Vehicle Dimensions
    - Approximately 255 inches in length, 102 inches in width and 129 inches in height
      (*Internal Air Transport Certification (ATTLA) – 2007.07.18.01, August 6, 2009)*
  - Vehicle Weight – Heaviest of its type on RT075 (Provided by NTSB)
    - 41070 LBS.

- MRAP ATV (M-ATV)
  - Vehicle Dimensions
    - Approximately 250 inches in length, 100 inches in width and from 100 to 144 inches in height
      (*Internal Air Transport Certification (ATTLA) – 2009.08.32 Rev 7, September 28, 2012 & 2009.08.32 Rev 8 June 25, 2013)*
  - Vehicle Weight – Heaviest of its type on RT075 (Provided by NTSB)
    - 27809 LBS.

747-400 BCF MRAP Tie Down Assessment for NTSB

Boeing Weight and Balance Manual Information

SPECIAL RESTRICTIONS FOR OPERATIONS WITH TALL RIGID CARGO

Tall rigid cargo is defined as cargo that is in excess of 96 inches tall and will not break apart during an emergency event (a 777 engine is an example of tall rigid cargo).

In an emergency landing event, tall rigid cargo must be stopped before it impacts the upper deck divider at B.A. 800. This will protect all of the upper deck occupants on the airplane.

To ensure this, a sufficient volume of cargo must be loaded forward of the tall rigid cargo. In an emergency landing event, this cargo will redistribute and fill up the main deck cargo volume between the B.A. 158.5 barrier and the tall rigid cargo. This volume of cargo will stop the tall rigid cargo from impacting the upper deck divider at B.A. 800.

(Boeing WBM D043U544-AFA1, Section 1-69-121 page 1 of 21)

747-400 BCF MRAP Tie Down Assessment for NTSB

Telair Weight and Balance Manual Information

11. MAIN DECK UNIT LOAD DEVICE LOCATIONS

11.1. LOADING CONSIDERATIONS

11.1.2 General

- An object is considered to be frangible if it will readily separate and conform to the airplane contour when subjected to a 9G forward load. Rigid cargo consists of items which will not separate nor conform to the airplane contour. Jet engines, wheeled vehicles, tugs and dollies are examples of rigid cargo.
- Unit load devices greater than 96 inches in height are restricted to positions aft of B.A. 777
- Rigid cargo over 96 inches in height have the following additional loading restrictions
  - The most forward rigid loaded device must be loaded aft of B.A. 1160 right side, aft of B.A. 1220 left side, or aft of B.A. 1220 center loaded
  - There must be a minimum of the equivalent of seven 125 inch long loaded unit load devices positioned directly forward of the rigid cargo greater than 96 inches in height
  - Carriage of an empty ULD cannot be counted as an occupied ULD position
  - Cargo loads which may cut or pass through the upper deck barrier net must be restrained to a 9G forward condition or be placed aft of loads (subject to the restrictions above) which will not penetrate or damage the barrier net.
  - In all cases the most forward 4 pallet positions forward of the rigid device must be loaded with frangible cargo

(Telair WBM 25-55-66, Section 11.1.2 page 55 of 145)

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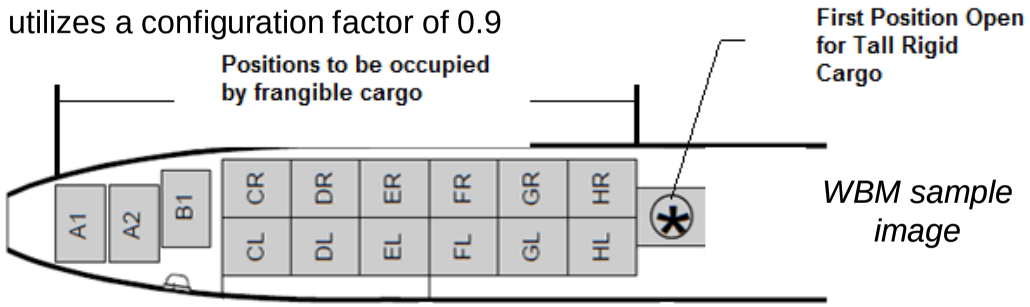
747-400 BCF MRAP Tie Down Assessment for NTSB

Tall Rigid Cargo: Frangible Volume

- Cougar is greater than 96 inches in height
  (Internal Air Transport Certification (ATTLA) – 2007.07.18.01)
- M-ATV is greater than 96 inches in height
  (Internal Air Transport Certification (ATTLA) – 2009.08.32 Rev 7 & 2009.08.32 Rev 8)
- Without additional modifications to lower the vehicle to 96 inches or less, this assessment considered both vehicles to be Tall Rigid Cargo per Boeing and Telair WBMs
  - For center loaded tall rigid cargo up to 148703 LBS., all positions from A1 through H must be loaded
  - Using the following:

1. Frangible cargo is loaded in all A positions, all B positions and all C positions
2. Positions D through H are loaded with frangible or rigid cargo
3. All positions use M size pallets, 100% full, and are full height as allowed by the position
4. Center loaded Tall Rigid Cargo utilizes a configuration factor of 0.9



WBM sample image

747-400 BCF MRAP Tie Down Assessment for NTSB

Response to NTSB Request #1 – Cougar

Boeing assessment of the possible Cougar restraint options consistent with the WBM & ATTLA documentation versions available at the time of the accident.

- Assessment uses the following:
  - Forward-most tie down available for use is B.A. 1281 resulting from required cargo volume for tall rigid cargo up to 148703 LBS., using optimized frangible cargo volume.
  - Cougar is loaded on a TSO-c90, size code G pallet, 238.5 inches in length by 96 inches in width (which was used to load the Cougar on the NAL event airplane).
  - Pallets are centerline loaded fully “floating” requiring tie down restraint in all directions.
  - Weight of Cougar is 41070 LBS.
- Assessment
  - Cougar cannot be carried on size code G pallet 96 inches wide due floor structural loading limitations. Tie down restraint of Cougar not assessed due to the floor structural limitations.
  - Using a size code G pallet, the weight of the Cougar requires it to be loaded on the airplane between B.A. 1000 and 1480
  - Aft of B.A. 1480 a centerline loaded size code G pallet can be loaded to 36,967 LBS maximum.
    (Boeing WBM D043U544-AFA1, Section 1-60-003 page 5 of 5 and Telair WBM 25-55-66, section 4.4 page 27 of 145)
  - The forward-most cargo location available begins at B.A. 1281, a size code G pallet 238.5 inches in length would extend beyond B.A.1480

747-400 BCF MRAP Tie Down Assessment for NTSB

Response to NTSB Request #1 – M-ATV

Boeing assessment of the possible M-ATV (MRAP ATV) restraint options consistent with the WBM & ATTLA documentation versions available at the time of the accident.

- Assessment uses the following:
  - M-ATV is loaded on a TSO-c90, size code G pallet, 238.5 inches in length by 96 inches in width.
  - Pallets are centerline loaded fully “floating” requiring tie down restraint in all directions.
  - Weight of M-ATV is 27809 LBS.
  - No auxiliary tie down Allowables (*Internal Air Transport Certification (ATTLA) –2009.08.32 Rev 7)*
  - Vertical restraint is performed with restraint straps going over the top of the vehicle

- Assessment
  - One M-ATV can be carried (further details on following slide)

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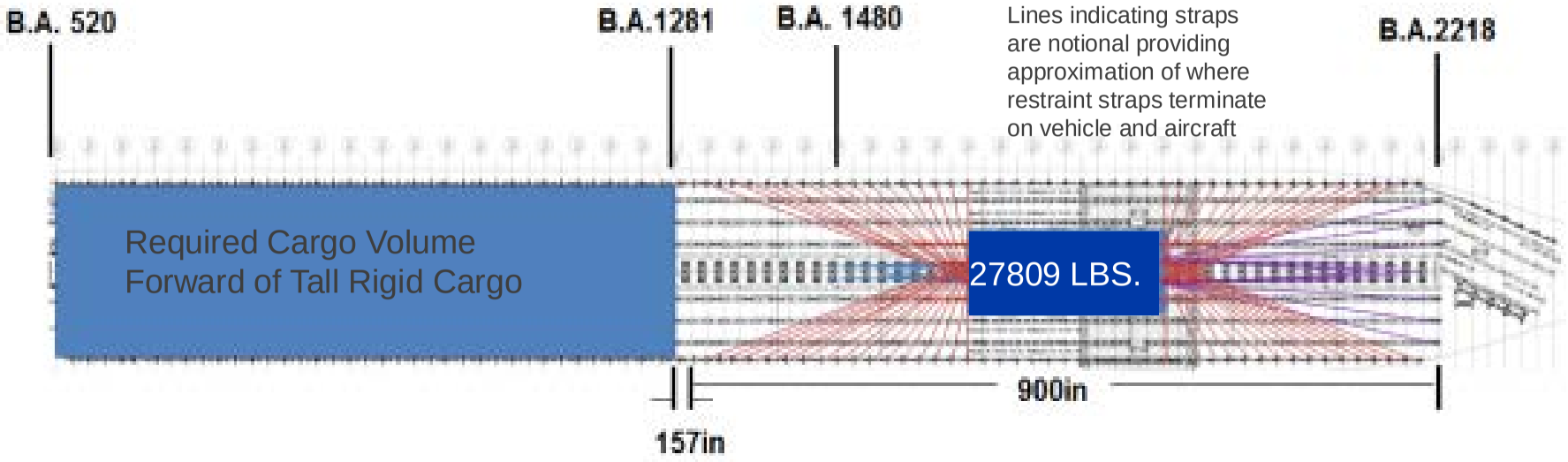
Response to NTSB Request #1 – M-ATV

Boeing assessment of the possible M-ATV (MRAP ATV) restraint options consistent with the WBM & ATTLA documentation versions available at the time of the accident (note: at the time of the accident only the front and rear attachments were approved for use).

- Assessment
  - One M-ATV can be carried
  - Required volume forward of tall rigid cargo for one M-ATV is B.A.520 through B.A.1281
  - Required volume forward of tall rigid is B.A.520 through B.A.1281, which does not allow sufficient area for a second M-ATV



747-400 BCF MRAP Tie Down Assessment for NTSB

Response to NTSB Request #1 – M-ATV

- Assessment (continued)
  - Tie down restraint of one M-ATV requires 60 straps per the following table:

Restraint Direction	M-ATV Tie Down Point	Number of Aircraft Tie Down Points	Aircraft Tie Down Type
Aft	Left Front Bumper	5**	Seat Track
		1**	Center Guide
	Right Front Bumper	5**	Seat Track
		1**	Center Guide
Left Side	Left Front Bumper	17*	Side Guide
	Left Rear Bumper	15*	Side Guide
Right Side	Right Front Bumper	17*	Side Guide
	Right Rear Bumper	15*	Side Guide
Forward	Left Rear Bumper	3**	End Stop
	Left Rear Bumper	2**	Center Guide
	Left Rear Bumper	5**	Seat Track
	Right Rear Bumper	3**	End Stop
	Right Rear Bumper	2**	Center Guide
	Right Rear Bumper	5**	Seat Track
Up	Over the Top	12	Seat Track
	Over the Top	8	Pallet Lock

*Two fittings per strap, with the remaining fitting attached to a single strap

** Two fittings per strap, each strap runs through both bumper fittings and attach similar fittings on opposite sides of the aircraft

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747-400 BCF MRAP Tie Down Assessment for NTSB

Response to NTSB Request #2 – M-ATV

Boeing assessment of the possible M-ATV (MRAP ATV) restraint options consistent with the WBM with the added assumptions that the MATV auxiliary tie downs are available for use per current ATTLA documentation (note: MAT-V auxiliary tie downs were not approved for use at the time of the accident).

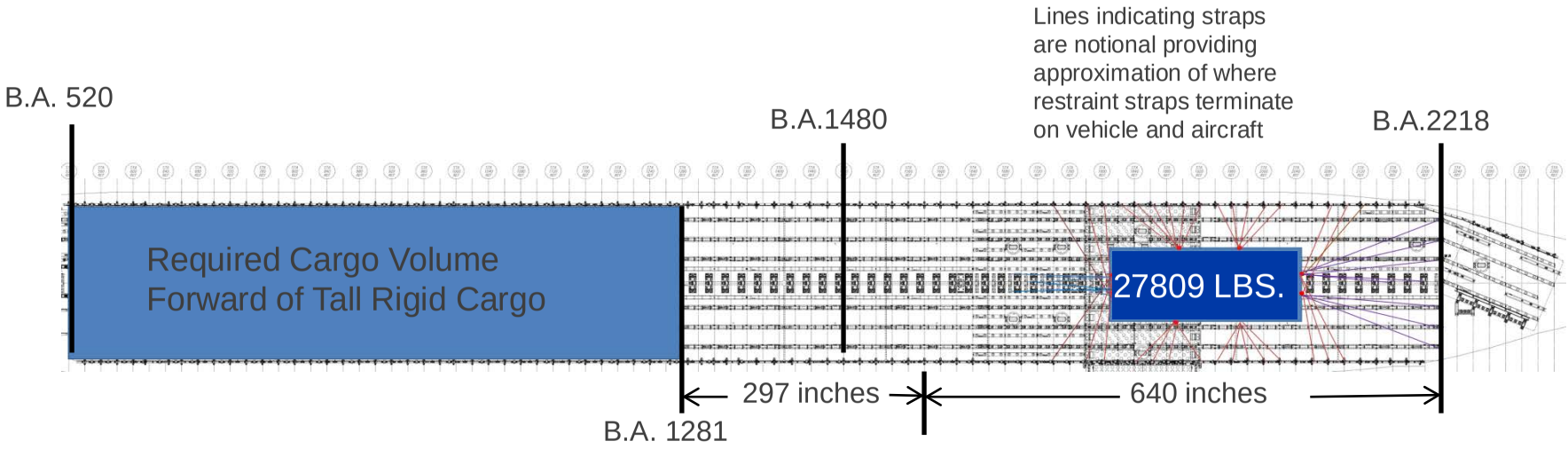
- Assessment uses the following:
  - M-ATV is loaded on a TSO-c90, size code G pallet, 238.5 inches in length by 96 inches in width.
  - Pallets are centerline loaded fully “floating” requiring tie down restraint in all directions.
  - Weight of M-ATV is 27809 LBS.
  - Auxiliary provisions are rated for 25,000 LBS lateral (*Internal Air Transport Certification (ATTLA) –2009.08.32 Rev 8)*
  - Vertical restraint is performed with restraint straps going over the top of the vehicle

- Assessment
  - One M-ATV can be carried (further details on following slides)

747-400 BCF MRAP Tie Down Assessment for NTSB

Response to NTSB Request #2 – M-ATV

- Assessment
  - One M-ATV can be carried
  - Required volume forward of tall rigid cargo for one M-ATV is B.A.520 through B.A.1281
  - Required volume forward of tall rigid cargo is B.A.520 through B.A.1281, which does not allow sufficient area for a second M-ATV
  - Auxiliary provisions used to account for lateral restrain of M-ATV only
    - however not permissible to use straps from auxiliary provisions to aircraft in only lateral direction as tie down locations on aircraft are forward and aft as well as lower than the auxiliary provision locations on the vehicle.
    - Fore/Aft and Vertical components of strap tension were assumed to be acceptable for developing the required lateral restraint load using the auxiliary provisions.



747-400 BCF MRAP Tie Down Assessment for NTSB

Response to NTSB Request #2 – M-ATV

- Assessment (continued)
  - Tie down restraint of one M-ATV requires 56 straps per the following table:

Restraint Direction	M-ATV Tie Down Point	Number of Aircraft Tie Down Points	Aircraft Tie Down Type
Aft	Left Front Bumper	5**	Seat Track
		1**	Center Guide
	Right Front Bumper	5**	Seat Track
		1**	Center Guide
Left Side	Left Front Bumper	12	Side Guide
	Right Front Auxiliary	6	Side Guide
	Right Rear Auxiliary	6	Side Guide
	Left Rear Bumper	6	Side Guide
Right Side	Right Front Bumper	10	Side Guide
	Left Front Auxiliary	4	Side Guide
	Left Rear Auxiliary	4	Side Guide
	Right Rear Bumper	9*	Side Guide
	Right Rear Bumper	2	Seat Track
Forward	Left Rear Bumper	3**	End Stop
	Left Rear Bumper	2**	Center Guide
	Left Rear Bumper	5**	Seat Track
	Right Rear Bumper	3**	End Stop
	Right Rear Bumper	2**	Center Guide
	Right Rear Bumper	5**	Seat Track
Up	Over the Top	8	Pallet Lock
	Over the Top	12	Seat Track

*Two fittings per strap, with the remaining fitting attached to a single strap
** Two fittings per strap, each strap runs through both bumper fittings and attach similar fittings on opposite sides of the aircraft

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